

USSN 09/523,491

REMARKSExtension of Time/Fees for this Response

A request for a two-month extension of time accompanies this response. The required fee is being submitted with this response.

Response to restriction requirement

Applicant hereby confirms the election of the group I claims, i.e., claims 1-24, without traverse.

Support for amendments

Support for the listing of metals in claims 7 and 17 is found in original claim 18. Support for the temperature ranges in claims 7 and 17 is found at page 26 lines 3-5 and in Figure 11.

Regarding the rejection of claim 3 under 35 USC §112

This rejection rendered moot due to the cancellation of claim 3.

Regarding the rejection of claims 1-5 under 35 USC §102(b) over Izumi

This rejection is rendered moot by the cancellation of these claims.

Regarding the rejection of claims 1-5, 7, 8, 11 and 14-16 under 35 USC §102(b) over Leem

This rejection is rendered moot with respect to claims 1-5 due to the cancellation of those claims. Claims 7, 8, 11 and 14-16 as amended all exclude aluminum as the metal layer to be formed. Leem only describes forming an aluminum layer in his process.

Regarding the rejection of claims 7, 8 and 12-17 and 20-22 as obvious over Izumi

Independent claims 7 and 17 as amended are drawn to a process for depositing a thin film of certain metals onto a substrate. The process includes contacting the substrate with certain metal halides (specifically a fluoride in claim 17) to form a metal halide surface. The metal halide surface is contacted with a silylating agent to form a metal-silicon surface, which is then contacted with more of the metal halide to form the metal surface. All reactions are performed at 425-600K. Good quality metal films are produced in this manner.

USSN 09/523,491

Izumi describes a prior art CVD (chemical vapor deposition process) and his own process for depositing metal films. In the prior art CVD process (see column 1 lines 10-55), a mixture of tungsten fluoride gas and a gaseous reducing agent is used to produce a tungsten film. That "prior art" process therefore is not at all similar to the sequential method described in the present claims. Izumi describes two types of reducing agents—hydrogen gas and silanes. Izumi states that temperatures of 400-500°C (673-773 K) are needed when hydrogen gas is used. Izumi also states that lower temperatures are suitable when silanes are used, but that the resulting films are contaminated with silicon, leading to certain inferior properties. Izumi does not say what those "low temperatures" would be.

In Izumi's process, the tungsten fluoride gas and the reducing gas are introduced "alternatively and discontinuously", and in that sense more closely resembles the applicant's process. Izumi specifically states that silanes are not to be used as his reducing gas because they contaminate the resulting thin metal film with silicon. See column 2 lines 49-51.

This is a classical case of a reference teaching away from a claimed invention. Izumi explicitly considered the possibility of using silanes as a reducing gas in his method, and just as explicitly rejected the idea because he felt that it would produce a contaminated film. Izumi further describes how, in conventional CVD processes where the tungsten halide and silane are introduced simultaneously, the metal film is contaminated. In view of these teachings, Izumi cannot fairly be read as suggesting that silanes could be incorporated into any process for making thin films with any reasonable expectation of success. The fact that Izumi associates using silanes with lower reaction temperatures does not provide motivation to use them, in view of Izumi's explicit teaching that doing so would produce poor quality films.

The applicants have found that silanes function as excellent reducing agents, provided that the metal film is deposited in a sequence of half-reactions at moderate temperatures as set forth in claims 7 and 17. As shown especially in Figure 4, silicon species that exist on the substrate surface after the silane addition are almost completely removed during the subsequent exposure to the metal halide. This largely avoids the

USSN 09/523,491

problem of silicon contamination and produces high quality metal films.¹ Izumi obviously does not recognize or suggest that this result would be achieved.

Regarding the rejection of claims 17 and 20-22 as obvious over Leem

Claims 17 and 20-22 as amended are limited to the formation of films of certain metals which do not include aluminum. Leem's process is limited to forming aluminum films.

Although Leem suggests that various reducing gasses (including silane) can be used, Leem does not provide any working examples that support the point. Subsequent publications provide a basis for doubting Leem's teachings regarding the range of reducing gasses that can be used to deposit aluminum films. Lee et al., "Atomic Layer Deposition of Aluminum Thin Films Using an Alternating Supply of Trimethylaluminum and a Hydrogen Plasma", *Electrochemical and Solid-State Letters*, 5 (10) C91-93 (2002), show that attempted deposition of aluminum from trimethylaluminum and hydrogen does not occur under the conditions employed (see paragraph bridging the columns of page C91). Lee et al. established that a hydrogen plasma is needed to be created in order for the deposition of aluminum to occur.

Therefore, Leem does not create a *prima facie* case of unpatentability of claims 17 and 20-22.

Regarding the rejections of claims 9, 10, 23 and 24 as obvious over Izumi in view of Pogge and Humphery and Leem in view of Pogge and Humphery.

Claims 9, 10, 23 and 24 share the feature that the substrate is contacted with a silylating agent prior to the metal film deposition. The secondary references are relied on to describe this feature.

As discussed above, neither Izumi nor Leem render the subject matter of the underlying independent claims obvious. Claims 9, 10, 23 and 24 are therefore patentable over each of these combinations of references, for the reasons already stated.

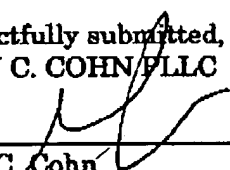
¹ Papers published by Drs. Klaus and/or George subsequent to the priority date of this application provide additional experimental verification of the quality of films made in accordance with the invention. See Klaus et al., "Atomic layer deposition of tungsten using sequential surface chemistry with a sacrificial stripping reaction", *Thin Solid Films* 360 (2000) 145-153 (see especially page 152, left-hand column); and Elam et al., "Nucleation and growth during tungsten atomic layer deposition on SiO₂ surfaces", *Thin Solid Films* 386 (2001) 41-52 (see especially p. 45, left-hand column just before section 4).

USSN 09/523,491

Conclusion

All claims now pending in this application have been shown to be novel and unobvious over the cited references. A timely notice of allowance is respectfully requested. The undersigned is available by telephone if a call would advance prosecution.

Respectfully submitted,
GARY C. COHN/PLLC



Gary C. Cohn
Registration No. 30,456
Phone: (425) 576-1656
4010 Lake Washington Blvd. NE
Suite 105
Kirkland, WA 98033

FAX RECEIVED
APR 21 2003
GROUP 1700

Enclosures:

Lee et al., Electrochemical and Solid-State Letters paper.

Klaus et al., "Atomic layer deposition of tungsten using sequential surface chemistry with a sacrificial stripping reaction", Thin Solid Films 360 (2000) 145-153.

Elam et al., "Nucleation and growth during tungsten atomic layer deposition on SiO₂ surfaces", Thin Solid Films 386 (2001) 41-52.